LETTER TO THE EDITOR

Determination of low level ^{210}Pb in tobacco

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The major objective of this study is to measure the low level ^{210}Pb activity as quantitative indicator of ^{210}Po as well as providing a convenient method with a NaI(Tl) detector using the standard addition method.

Introduction

The presence of ^{210}Pb in tobacco is of special interest because it is a long-lived (22.3 y) precursor that supports the alpha emitting radionuclide, ^{210}Po.

Until recently, a direct determination of low level ^{210}Pb was rather difficult, because it emits only low energy β- and γ-rays in its radioactive decay.[1] Generally, the quantitative determination of ^{210}Pb is carried out by measuring the β- or α-activity of its daughter ^{210}Bi and ^{210}Po, respectively, after tedious and time-consuming chemical separations. ^{210}Pb can also be determined by direct counting of its 46.5 keV γ-line.[2,3] Gamma-spectroscopy has the advantage of a non-destructive method, but it needs correction for self absorption of γ-rays in the sample matrix.[3,4,5] Another disadvantage is the low emission probability of the gamma line (4.26%).[3]

For this reason, the measurement of low level ^{210}Pb activity in environmental samples creates some difficulties, so one has to establish a proper method which is essential. Although the standard addition method is quite general, it was originally applied for γ-ray spectroscopy.

Experimental

We studied the ^{210}Pb activities in thirteen different types of tobacco plants grown in various regions of Turkey.

Sample preparation

The tobacco leaves were oven-dried at 105 °C to get constant weight and ashes at 450 °C in an electric furnace. By ashing the plants ^{210}Pb is highly concentrated. About 110 mg ash is produced from 1 g dry tobacco.

According to the required procedure for standard addition,[6] a small amount of ^{210}Pb standard of known activity was added to the ashed samples (9 g) excluding one. Additions of the standard were equal to approximately half, one and to twice the amount of the ^{210}Pb activity estimated in the original sample for the optimum statistics as suggested.[6]
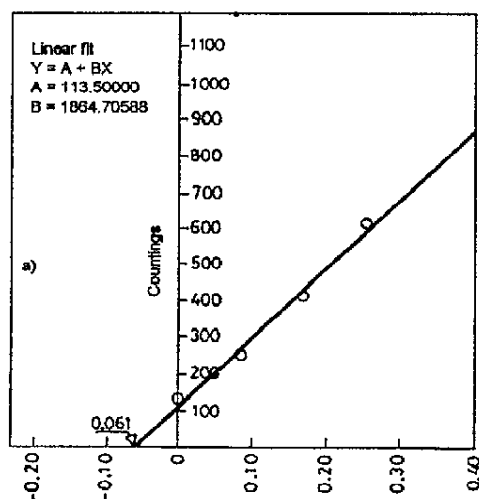
The ^{210}Pb standard was prepared from ^{210}Pb solution manufactured in 1969 by Baird Atomic diluted with a non-radioactive matrix such as extra pure starch (Merck). The present ^{210}Pb activity in the standard was calculated to be 2.39 $Bq \cdot g^{-1}$ as refer to original solution.

Finally all samples were diluted to the same quantity (14 g) with starch and were extremely well mixed to avoid the possibility of radioactive source inhomogeneity. They were then pressed into pellets of 40.6±0.2 mm radius and 7.0±0.1 mm thickness under a pressure of 300 $kg \cdot cm^{-2}$ for providing an easily repeated geometry.

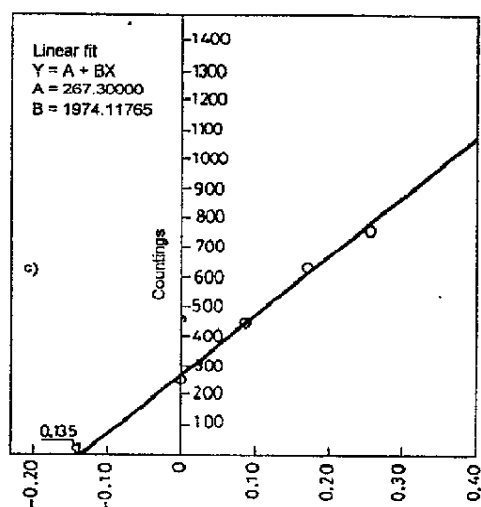*Equipment*

The emission rate of 46.5 keV γ-rays of ^{210}Pb from each sample was measured using a 38 mm×19 mm NaI(Tl) detector with a Be window, and a 4k channel analyzer (Ortec – 7010 Model). The detector was kept in a 50 mm thick cylindrical lead shield of 150 mm inner radius.
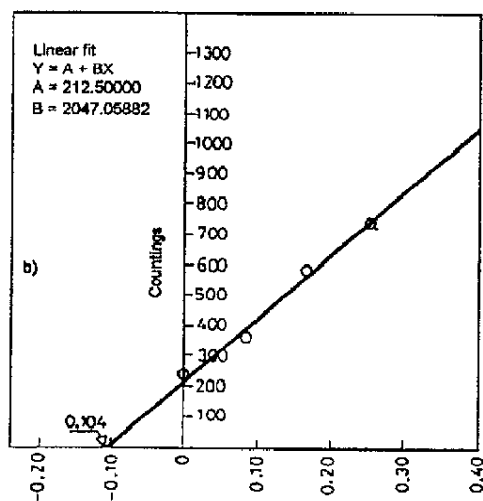
In a spectrum taken with a HPGe detector the 46.5 keV γ-line of ^{210}Pb will be very well resolved from nearest γ-emission due to naturally occurring ^{212}Bi (39.9 keV) and ^{212}Pb (53.2 keV) since the energy resolution of this solid-state detector is extremely high. For example at 122 keV, a FWHM between 400–600 eV is very common for HPGe, where as 16 keV is given for NaI (Tl) crystal. On the other hand, the efficiency of the solid – state γ-detector is only about 3–20% of that NaI(Tl) detectors.[7]
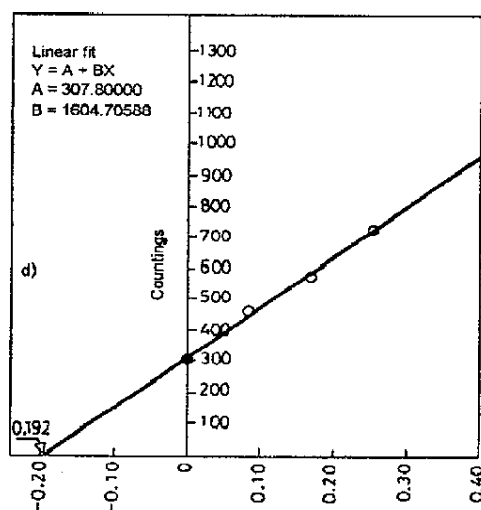
a)

Linear fit
Y = A + BX
A = 113.50000
B = 1864.70588

Countings

0.061

Activity of Pb added to tobacco sample, Bq / g
Correlation coefficient: 0.992547

c)

Linear fit
Y = A + BX
A = 267.30000
B = 1974.11765

Countings

0.135

Activity of Pb added to tobacco sample, Bq / g
Correlation coefficient: 0.996644

b)

Linear fit
Y = A + BX
A = 212.50000
B = 2047.05882

Countings

0.104

Activity of Pb added to tobacco sample, Bq / g
Correlation coefficient: 0.995665

d)

Linear fit
Y = A + BX
A = 307.80000
B = 1604.70588

Countings

0.192

Activity of Pb added to tobacco sample, Bq / g
Correlation coefficient: 0.992547

Fig. 1. Graphic representations of the standard addition method for the determination of ^{210}Pb activity in tobacco samples
as TTOM(a). TIZM(b), TBIT(c), TBAF(d)

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When it is impossible to suppress physical or chemical interferences in the sample matrix, the standard addition may be used as it is given previously.[6]

Determination limit (DL)

To illustrate the sensitivity of the system for the determination of ^{210}Pb in tobacco, the approximate determination limit was calculated. Applicability of such DL derived by CURRIE[8] depends upon the assumptions made in calculations, which involve determining the true mean background (μ_β) and in deciding whether the observations fall under the "paired observations", i.e., only one single measurement is available or "well known blank", i.e. background is precisely known from several previous measurement category.[5] According to CURRIE[8] the determination limit value with a 10% analytical error was derived by the expression:

$$DL = LQ/(\text{count time}[s] \times (\text{fractional efficiency of the detector}) \times (\text{ratio for } \gamma \text{ emission}) \text{ dps}$$

$$LQ = 50 \{1 + [1 + \mu_\beta/25]^{1/2}\}, \text{ counts}$$

According to the above mentioned the determination limit (DL) was estimated about 0.10 dps for a counting time of 4000 seconds.

Results and discussion

The graphic solutions using the standard addition method for the tobacco samples chosen randomly and labelled as TTOM, TIZM, TBIT, TBAF are shown in Fig. 1.

The activity scale (*x*-axis) is determined by the activities of ^{210}Pb standard added to the tobacco samples and thus the unknown activity of the original sample is given by the point at which the extrapolated line intersect the activity axis.

The findings expressed on dry weight basis are tabulated in Table 1.

Table 1. Activities of ^{210}Pb in tobacco leaves

Sample	^{210}Pb
TIZM	11.44 ± 1.72
TBUC	14.08 ± 1.81
TBUR	22.08 ± 1.96
TTOM	6.70 ± 1.78
TAGO	23.50 ± 1.87
TADI	18.92 ± 1.97
TYAY	26.57 ± 1.92
TSAR	20.31 ± 1.82
TBIT	14.89 ± 1.79
TBAS	14.61 ± 1.79
TRAB	8.24 ± 2.00
TSAM	15.37 ± 1.84
TBAF	21.09 ± 1.88

* Activities are given in mBq·g^{-1} dry weight.
** Errors are expressed as one standard deviation (1 σ).

The ^{210}Pb activities in tobacco plants were found to range from 6.7 to 26.57 mBq·g^{-1} as well as indicated ^{210}Po activities. Since the tobacco is normally cured and aged for 1–2 years after harvest before marketing, secular equilibrium of ^{210}Po with ^{210}Pb would be attained before the same is used.[9] Any ^{210}Po supported by ^{210}Pb which might be present in the plant at harvest would largely disappear by radioactive decay during the aging period.[10] Therefore ^{210}Pb is the main source and precursor of ^{210}Po in tobacco plant. ^{210}Pb activities range from 2.59–50.32 mBq·g^{-1}.[11]

In this sense the measurement of ^{210}Pb activities in tobacco are quite important from the public health point of view, considering the large smoking population in Turkey.

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